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RESPONSE CHARACTERISTICS OF XM33 LAUNCHER
WITH AND WITHOUT BLAST DEFLECTORS (U)

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RESPONSE CHARACTERISTICS
OF XM33 LAUNCHER WITH AND WITHOUT
BLAST DEFLECTORS $(\mathcal{U})$

By

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Approved by:

ARNOLD A. KESTER
Chief, Design Engineering Branch

14 February 1958

Rock Island Arsenal
Rock Island, Illinois

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SUMMARY

This study deals primarily with the response character-istics of the XM33 Rocket Launcher under initial firings conducted at White Sands Proving Grounds. The launcher system was mounted on 3-dimensional load cells at the four ground floats with displacement measuring potentiome-ters at various points along the length of the beam. Two rounds were fired from the Launcher. Round No. 1 was with blast deflectors mounted on the sides of the rail and round No. 2 was without deflectors. The results of these two rounds were to be interpreted as to the stability and response characteristics for tactical firing.

The launcher exhibited forces which indicated a de-gree of hold down was required to protect the system against translation type of motion. Comparing round No. 1 which had deflectors, with round no. 2 without deflectors, it was noted that the systems responded differently. Al-though the interpretation of the information, in terms of translational motion, could not be directed towards blast deflector action, the blast deflectors did exhibit hold down qualities or stabilizing moments. These were deemed necessary to keep the launcher beam from rebounding into the path of the rocket during the period, from end of guidance until the rocket cleared the rail, and also to maintain positive load on the rear floats. Significance of blast deflectors will be pointed out in the remainder of this report in more detail. It is to be noted specifically that the blast deflectors are not the contributing factors towards the high forces generated in the horizontal direction, causing large magnitudes of translation when tactically emplaced with no ground anchorage.

CONCLUSION

In conclusion it may be stated that the elements of the system have been designed for a specific effect and that these effects have occurred in proper sequence, but the magnitude of effect has not been fully defined. One specific conclusion reached is that dynamic stability of rocket launchers is more meaningful than static stability, and will contribute to better launcher design from the standpoint of a weight rigidity ratio. To be more specific, the XM33 Launcher was designed to support approximately 1/4 of the weight of the missile when suspended at the end of guidance. This indicates that statically it was only 1/4g stable. The response of this system dynamically showed no indication of being unstable. It can further be concluded through this study that the major horizontal

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reactions specified have been generated from the effects of blast impinging on the frontal area of the complete launcher. The effects of blast due to blast deflectors on the side of the rail in terms of horizontal loads are less significant when considering the gross loads.

RECOMMENDATIONS

It is recommended that the "A" Frame of the present launcher be reduced in terms of frontal area which is being subjected to the blast. Steps should be taken to incorporate an effective analysis from the standpoint of aerodynamics and generation of force vectors. This will give stabilizing moments to hold the system in restraint with reduction of horizontal load conditions. It is further recommended that some consideration be given to replacing the 4-point ground suspension with a 3-point system. More study should be initiated in terms of cross sectional inertias of the undercarriage structure. This is due to twist in the horizontal plane and in bending due to wheel reactions under traveling loads.

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OBJECT

The object of this study was to determine the response characteristics of the launcher; to study the instrumentation from the two rounds fired; to determine the magnitude and direction of forces induced into the launcher; and to interpret these forces into motion expected in the system. It was further conducted to attempt to define where these loads were being generated and what parts of the system would require redesign to facilitate a more optimum solution for further development.

INTRODUCTION

To analyze the system, it was necessary to define specific parameters which it was felt would be indicators as to how the system responded. By plotting the forces of the system in terms of vertical reactions on the front floats; vertical reactions on the rear float; and a summation of all horizontal loads in time sequence with each other, we are able to visually analyze how the system is responding with respect to the displacement of the missile on the beam; and displacement of the missile down range within the varied time period of the instrumentation.

PROCEDURE

The two illustrations in this report show the blast effect on the launcher when firing the 762MM rocket at 11° elevation and 0° traverse. Round No. 1 was fired with blast deflectors on the launcher beam, and round no. 2 was fired with the blast deflectors removed from the beam.

In the illustrations the launcher beam is shown in place at the upper left with the nozzle end of the rocket shown in various positions in relation to the beam. The magnitude and direction of the ground reactions are shown immediately below in relation to time and length of rocket travel.

At the lower left is shown the potentiometer readings, depicting the beam deflections at the various potentiometer stations. The potentiometers were set for zero reading with the rocket in place on the beam before firing.

At the lower right is shown the beam deflections for various positions of the rocket in relation to the beam. Here the straight lines designated as zero load show the

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position of the rail before the rocket was placed on the beam, and the elastic curves show the rail in relation to the zero load line and as such also in relation to the ground line.

Viewing the longitudinal ground reactions in the graphs, we can see that in the beginning of the rocket travel the launcher is being pushed forward due to the friction between the rocket and the rail. In round No. 1, the blast force on the launcher overcomes this friction force after 9 feet of travel, and begins to push the launcher rearward. In round No. 2, this same thing takes place after 13.5 feet of travel. The first peak and the following dip in the longitudinal load curve take place at the same time in the two rounds fired, and they are of approximately equal magnitude. In round No. 1, when the nozzle end of the rocket has passed the tip of the rail, the blast is directed to the underside of the beam and the elevating "A" frame with an increasing longitudinal load on the launcher. This load reaches a maximum of 12,000 pounds after 67 feet of rocket travel, while in round No. 2 it reaches a maximum of 10,000 pounds after 82 feet of rocket travel. That the blast is directed increasingly more to the underside of the beam is due to the fact that the rocket drops vertically away from its original path of flight. So that for example after 67 feet of travel, the rocket will have dropped about 17 inches, and after 82 feet of travel the drop will be 24 inches.

In the beginning of the rocket travel, the load on the front floats increases as the rocket moves forward on the rail. This load increase continues until after 15 feet of travel when the rocket is in free flight. In round No. 1, after 87 feet of travel, the blast effect lifts the front floats slightly off the ground. In round No. 2 this same thing takes place after 82 feet of travel and coincides with the maximum longitudinal load.

When the nozzle end of the rocket has passed the tip of the rail and the blast is directed toward the underside of the rail, the reactions on the rear floats take the form of a measured rhythmic beat that is particularly pronounced in round No. 1.

The potentiometer readings show that the rail deflection is greatest at the tip of the beam at station 7, while at station 12, the deflections are of a very small magnitude, thus indicating the rigidity of the launcher structure near the trunnion. Viewing the curve for station 7 in round No. 1, we see that the first cycle of beam deflections is

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completed after .31 seconds of movement, while the second cycle is completed .105 seconds later. In round No. 2, the first cycle is completed after .32 seconds of movement, while the second cycle was apparently completed .13 seconds later. Due to the blast effect, the potentiometer readings become unreliable after .43 seconds of movement.

We will now view the beam deflections at various rocket positions. The rocket is designed to be placed on a rigid rail with an original pitch of 0° 54'. It can be seen by comparing the zero load line with the elastic curve, that when the rocket is placed on the XM33 Launcher, the rocket has lost some of its intended pitch. This is due to the rigidity of the launcher structure at the trunnion compared to the more flexible support at the front. When the rocket starts its free flight, it will have lost 0° 6' of its originally intended pitch.

In round No. 1, the aforementioned two flexure cycles are clearly visible, while in round No. 2 the second cycle is incomplete.

Attention should also be directed toward the rear vertical loads on both rounds. During the guidance period on round No. 1 with deflectors, it will be noticed that the rear floats increase in downward load while in round No. 2 the rear floats decrease in downward load as the rocket moves along the rail. The significance here is that the blast deflectors are being effective in early stages of launch tending to hold rear floats on the ground.

RESULTS

The results of this study indicated the severeness of the blast effect due to the frontal area of the "A" Frame of the launcher. It further indicated that ground anchoring will be necessary to restrain the launcher against translation motion, and that a certain amount of overturning moment causing lift of the front floats off the ground is predominate in the system. This is verified by the inclosed graphs showing the vertical front float reactions at approximately 85 feet of rocket travel. It will be noted that the horizontal reactions are a maximum and that the front float reactions are 0 or slightly below but not enough to cause motion in the system. Comparing round No. 1 to round No. 2, with respect to the rear float vertical reaction during the guidance period, indicates the significance of blast deflectors. It can be seen in round No. 1, which had the rail deflectors, that the rear float reactions which would

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normally reduce, actually increase with respect to the motion of the missile on the rail. In comparison to round No. 2 which did not have the deflectors, it can be seen that the rear float vertical reactions reduced, as would normally be expected. The indication here is that the blast deflectors are supplying a force vector, maintaining the rear floats with a positive load.

Further significance in the effect of deflectors can be seen when analyzing the plotted elastic curves of the beam at different displacements of the rocket. It will be noted that immediately after the end of guidance, round no. 2 indicates a rebound of the total rail in considerable magnitude. Whereas round no. 1 with deflectors at the same time and displacement indicates that only the tip of the beam is rebounding upward and that the remainder of the beam is being held in restraint. It should be further noted that as the rocket nozzle clears the tip of the rail that the beam tip has already rebounded and is now at the lower position of its rebound cycle. This is possibly an explanation as to why the interference problem has not materialized. It should be known that with the deflectors mounted on the rail, the chances of interference with the rocket are highly minimized. Without the deflectors, it is expected that the system will be marginal as to tip-off characteristics. With reference to the potentiometer readings taken in stations 7 through 12 and plotted on inclosed drafts, the effects of blast deflectors can again be evaluated. The magnitudes and the time sequence of rebound has been altered as indicated by these traces.

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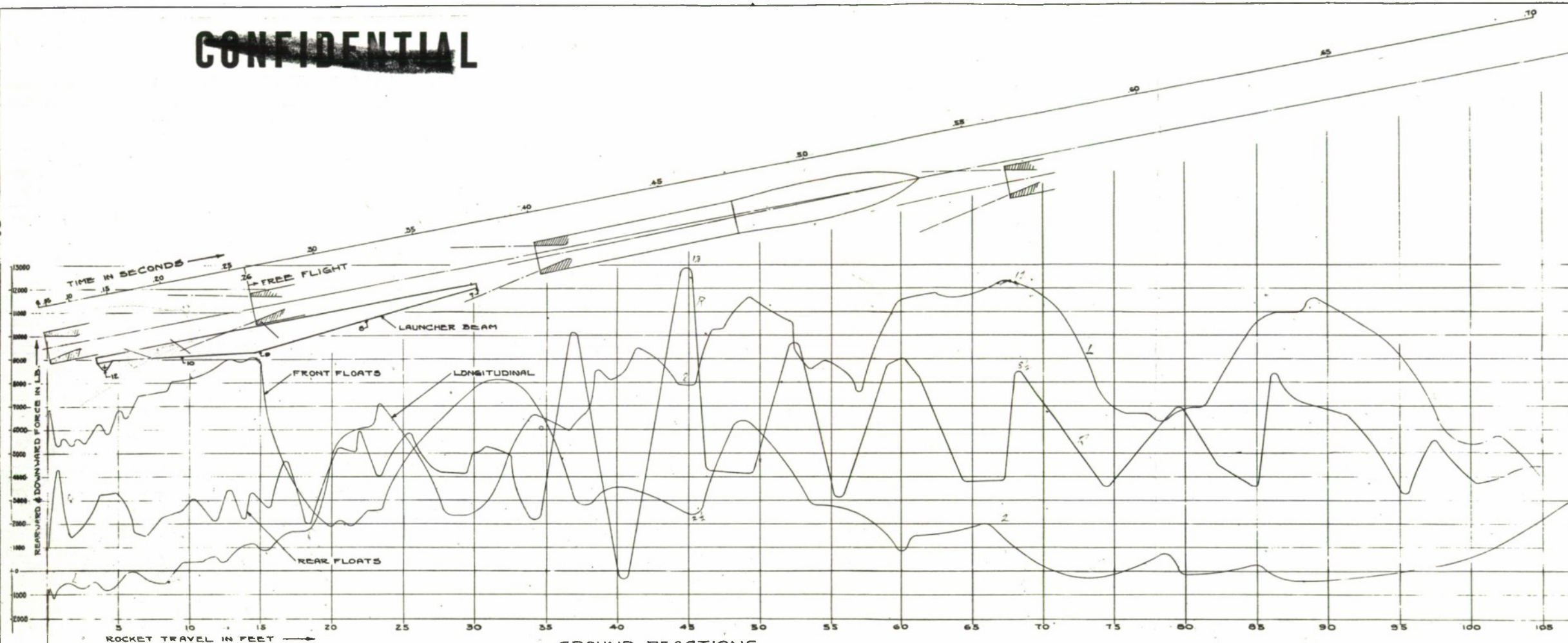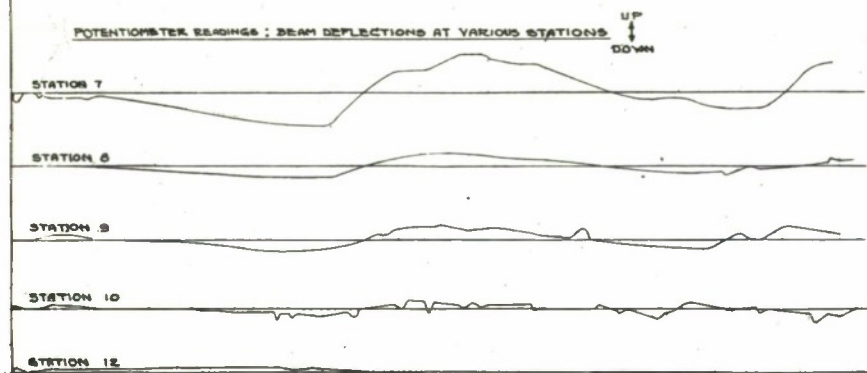
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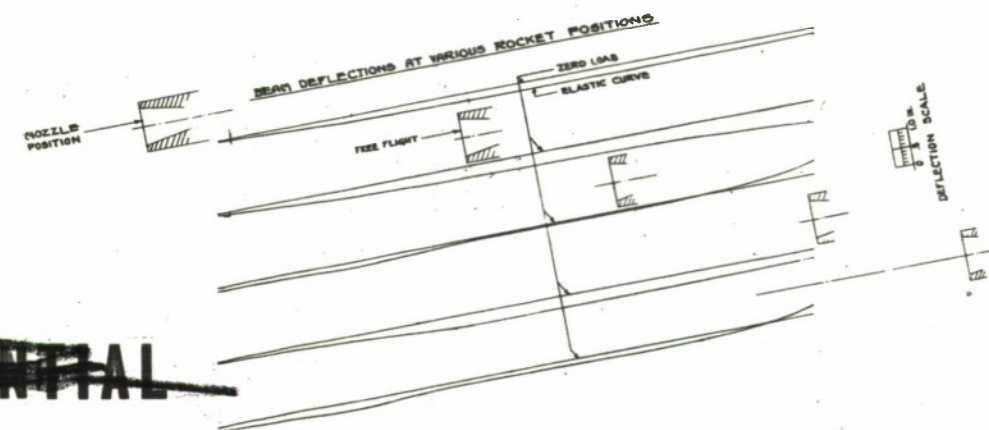   Attn: Technical Refer-
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APPENDIX

DRAWINGS

GROUND REACTIONS.
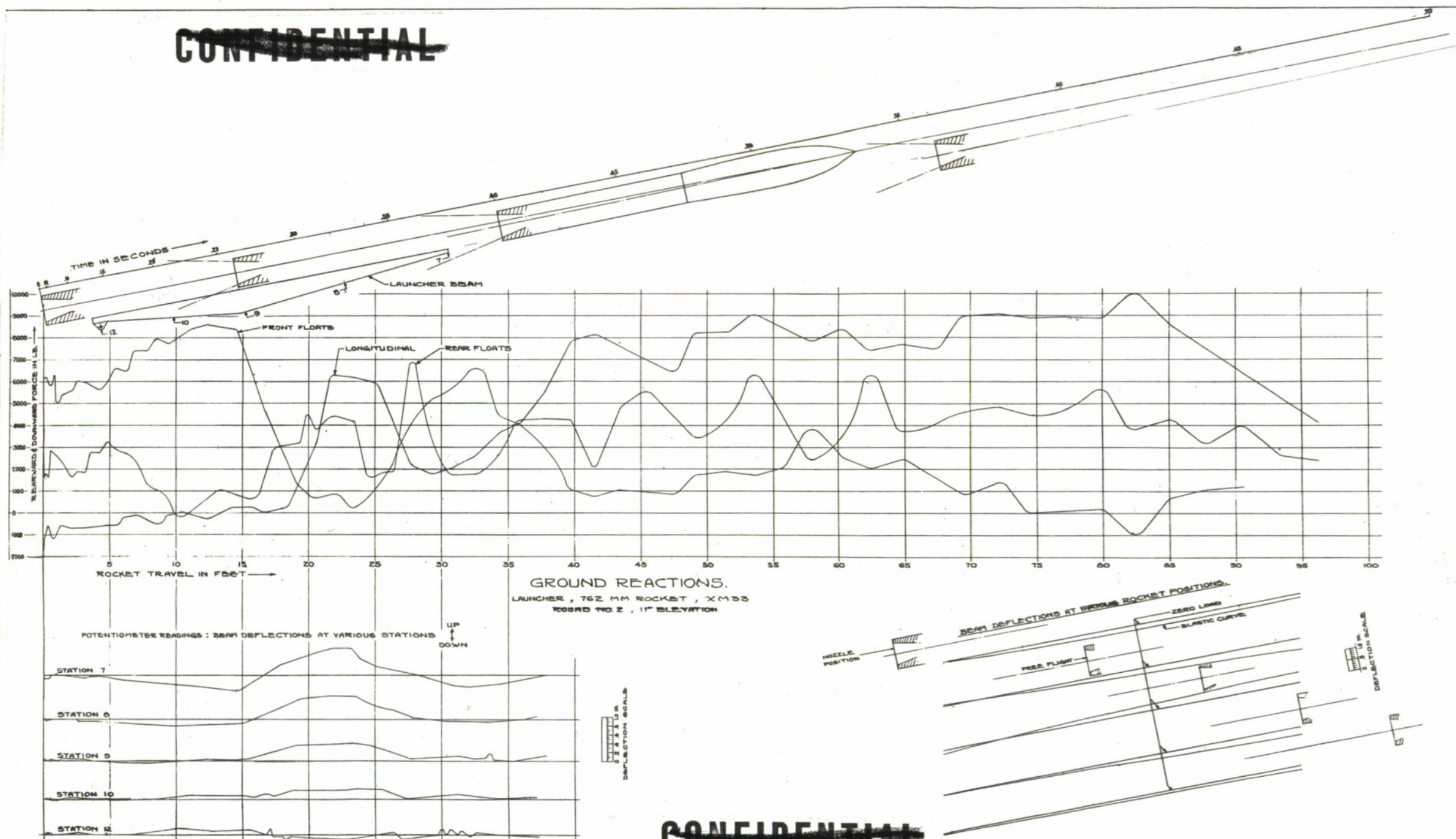LAUNCHER, 762 MM ROCKET, XM33
ROUND NO.1, 11° ELEVATION.

POTENTIOMETER READINGS; BEAM DEFLECTIONS AT VARIOUS STATIONS

BEAM DEFLECTIONS AT VARIOUS ROCKET POSITIONS

TIME IN SECONDS

LAUNCHER BEAM

FRONT FLOATS

LONGITUDINAL   REAR FLOATS

TELEMEASURED & DOWNWARD FORCE IN LB.

ROCKET TRAVEL IN FEET

GROUND REACTIONS.

LAUNCHER , 762 MM ROCKET , XM33
ROBAD NO. 2 , 11° ELEVATION

POTENTIOMETER READINGS : BEAM DEFLECTIONS AT VARIOUS STATIONS

UP
DOWN

STATION 7

STATION 8

STATION 9

STATION 10

STATION 12

DEFLECTION SCALE

BEAM DEFLECTIONS AT VARIOUS ROCKET POSITIONS.

ZERO LOAD

ELASTIC CURVE

NOZZLE
POSITION

FREE FLIGHT

DEFLECTION SCALE